ENAMELS. COATINGS

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A WASTE-BASED GLASS CERAMIC MATRIX FOR HEAT-RESISTANT COATINGS

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The authors consider an efficient solution of the problem of synthesis of glass ceramic heat-resistant coatings with a devitrified structure intended to protect expensive and scarce steel and alloys from high-temperature corrosion. A glass ceramic matrix is developed on the basis of metallurgical industrial waste.

In the conditions of the market economy, one of the most important requirements of making competitive products is the use of technologies that ensuring not only high quality but also savings in consumed resources. Of special theoretical and practical interest is studying industrial waste with the view of developing glass-composite heat-resistant coatings intended for protection of expensive metals and alloys from high-temperature corrosion.

Silicate coatings are the most promising for high-temperature protection of metals. However, vitreous enamels when serving at high temperatures become liquid-viscous and unable to provide effective protection from oxidation. The most effective are glass ceramic coatings, whose temperature of formation on the substrate surface coincides with the service temperature.

Heat-resistant glass ceramic coatings developed on the basis of the system $R_xO – Al_2O_3 – SiO_2 – TiO_2$ (where R is Li^+, K^+, Na^+, Mg^{2+}, Ca^{2+}, Ba^{2+}) and intended for high-temperature protection of nichrome steel and alloys possess good technological and functional parameters (USSR Inventor's Certif. No. 1805101). The technology of producing such coatings is expensive, as it requires chemically pure components for the synthesis of the glass matrix and for the preparation of the coating slip. In this context, the high-aluminum waste generated by metallurgy was investigated with the aim of using it as the basis for the synthesis of a glass matrix for protective coatings. The waste has the following chemical composition (wt.%): 15.14 SiO_2, 72.23 Al_2O_3, 1.95 Fe_2O, 1.77 CaO, 5.55 MgO, 0.32 TiO_2, 0.052 MnO_2, 2.22 K_2O, 1.59 Na_2O.

The synthesis of the glass matrix for such coatings was implemented on the basis of the system $R_xO – Al_2O_3 – SiO_2 – TiO_2$ (where R is Li^+, Na^+, K^+, Ca^{2+}, Zn^{2+}, Mg^{2+}, Ba^{2+}). The glass was melted in the laboratory conditions in an electric furnace with Silit heaters within the temperature interval of 1250 – 1300°C for 2 – 3 h. As a consequence of replacing chemically pure Al_2O_3 in the glass batch by the aluminum-bearing metallurgical waste, the temperature of the glass matrix synthesis was lowered by 100°C. The temperature of the coating formation on nichrome is 1000°C, and the firing duration is 3 min.

The differential-thermal analysis was performed on the glass matrix synthesized on the basis of waste (Fig. 1). The thermographic study demonstrated that the main crystalline phases in the glass matrix can be formed under heat treatment at temperatures 620 and 760°C. The observed endothermic effects (550 and 700°C) have a positive role in the synthesis of glass ceramic coatings.

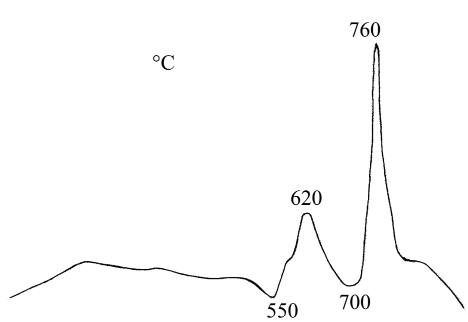

Fig. 1. Glass matrix thermogram.

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The physicochemical properties of the developed glass matrix were investigated both in the initial and in the heat-treated state. Heat treatment was carried out in accordance with the DTA data, and exposure duration was found experimentally.

On the basis of the performed studies, a glass matrix composition was developed for heat-resistant glass-composite coatings with the glass-ceramic structure, and the optimum conditions for glass devitrification in the considered system were identified.